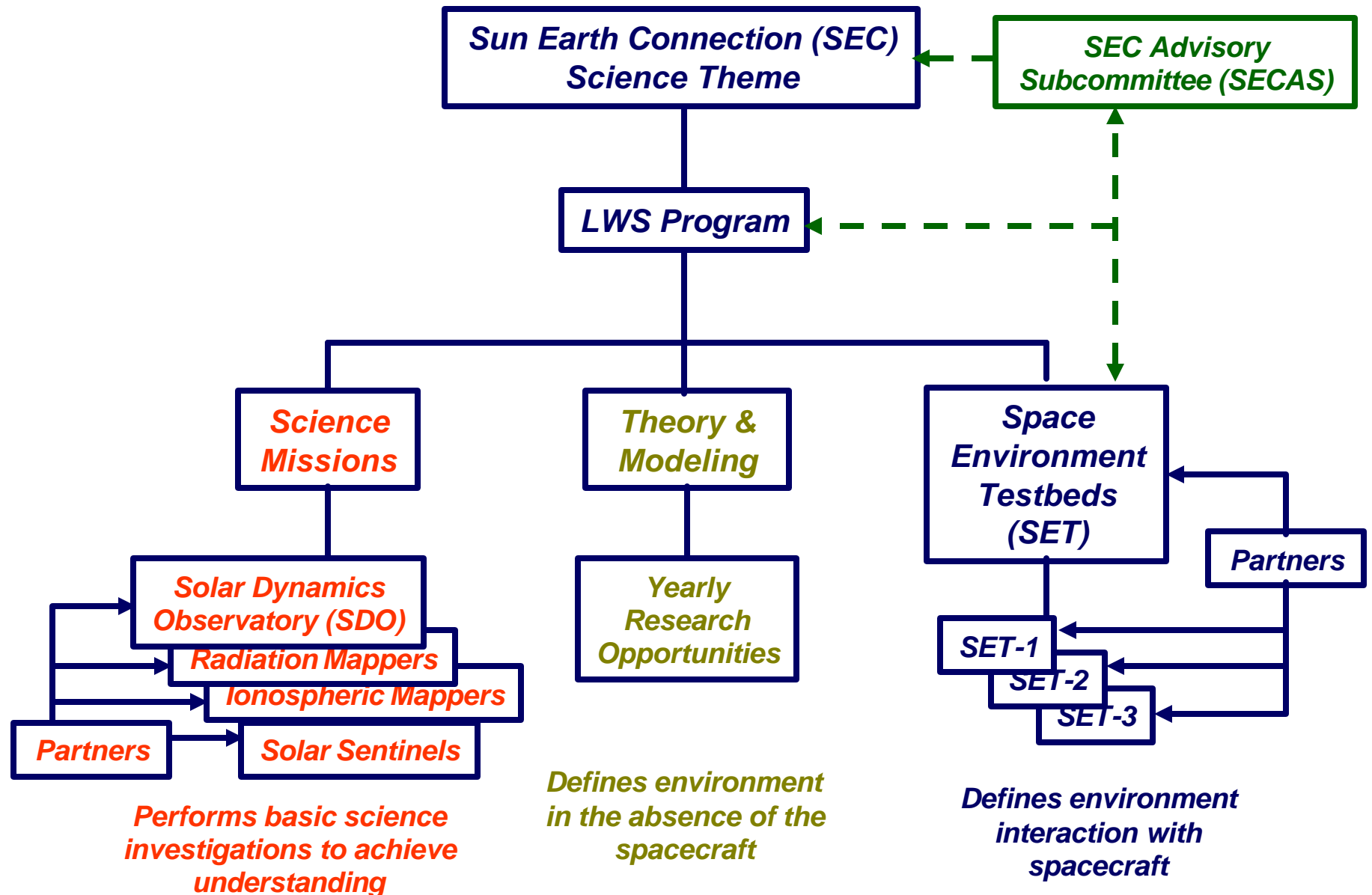# Living with a Star (LWS)
Space Environment Testbeds (SET)
Status

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June 20, 2003

Living With a Star (LWS) Program Architecture

Sun Earth Connection (SEC) Science Theme

SEC Advisory Subcommittee (SECAS)

LWS Program

Science Missions

Theory & Modeling

Space Environment Testbeds (SET)

Solar Dynamics Observatory (SDO)

Radiation Mappers

Ionospheric Mappers

Partners

Solar Sentinels

Yearly Research Opportunities

Partners

SET-1

SET-2

SET-3

Performs basic science investigations to achieve understanding

Defines environment in the absence of the spacecraft

Defines environment interaction with spacecraft

Living With a Star Space Environment Testbeds (SET)

Objective

Improve the engineering approach to accommodate and/or mitigate the effects of solar variability on spacecraft design & operations

Approach

? **Collect data in space to validate the physical mechanisms for performance degradation in the space environment**

? **Collect data in space to validate new & existing ground test protocols for the effects of solar variability on emerging technologies**

? **Develop & validate engineering environment models, tools, & databases for spacecraft design & operations**

Scope

Spacecraft hardware & design /operations tools whose performance changes with solar variability
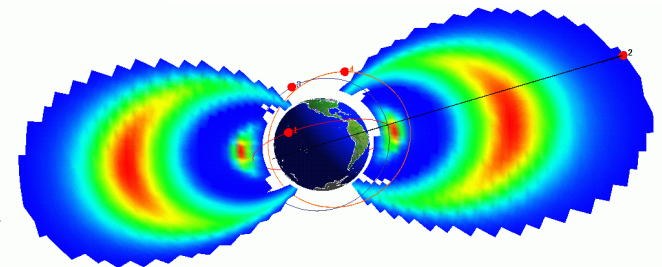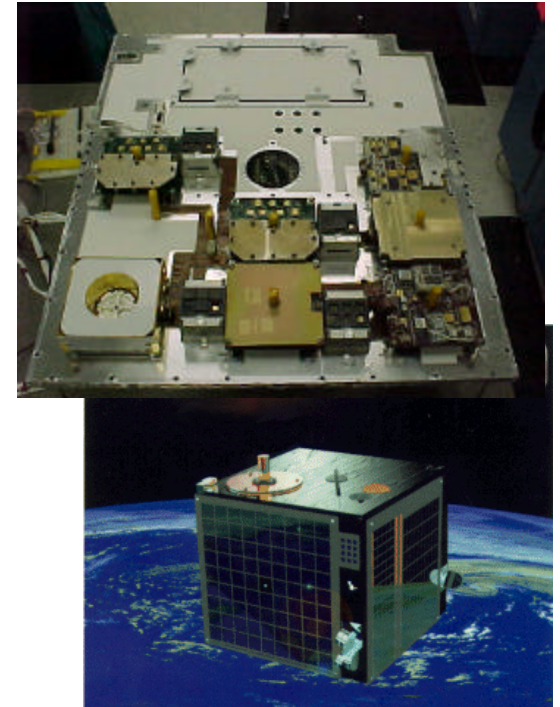
Space Environment Testbeds (SETs): 2 Components With Competed Investigations

NASA Research Announcement (NRA) 8-31: 8 Awards in 3/02

This NRA

NRA 02-OSS-04 for SET-1 Investigations: Awards 5/03

SET Data Analysis Component:

- *Models, tools, or databases that describe performance variations in space in the presence of a spacecraft that change due to solar variability*
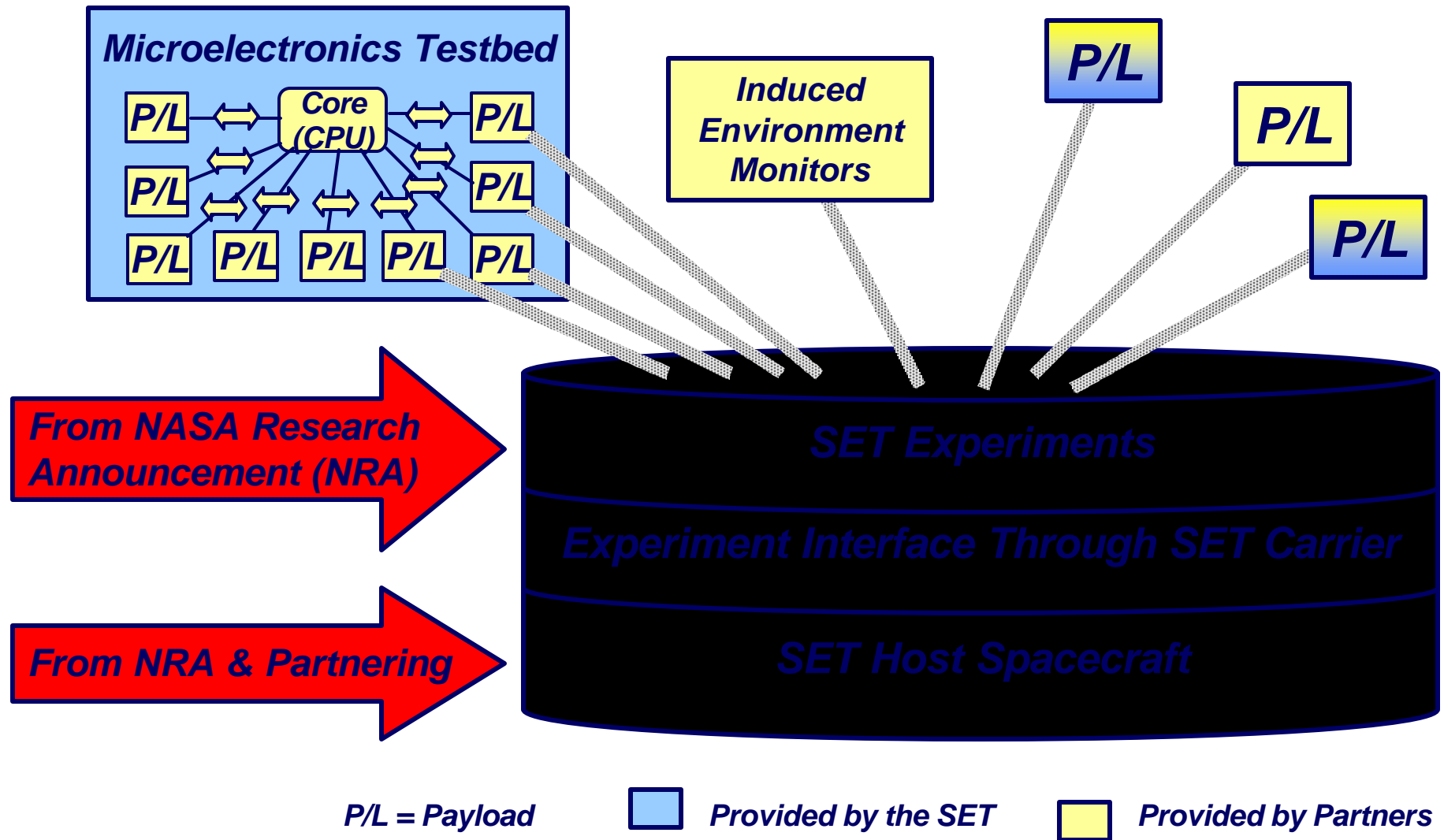- *5 of 8 reports available now; 3 have contract extensions*

SET Space Flight Component:

- *Investigations that include data collection from an experiment in space whose data are used to improve the physics-based understanding of response of systems to the solar varying space environments*
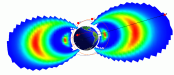- *Technology for >1 mission*

Awards from SET Data Analysis NRA

- ***Analysis of CRRES Pulse Height Analyzer (PHA) Data for Low-Linear Energy Transfer (LET) Events***
- ***Solar Variability, the Near-Earth Radiation Environment, and Transient Effects on Microelectronics***
- ***Displacement Damage Effects in Solar Cells-Mining Damage Data from the Microelectronic and Photonics Testbed (MPTB) Space Experiment***
- ***Modeling Charge Collection in Detector Arrays***
- ***Study of Total Ionizing Dose Effects of High-Z Material Spot Shields on Field Programmable Gate Arrays (FPGA) Using Flight Data from Microelectronics and Photonics Testbed (MPTB) Experiment***
- ***Characterization of Magnetospheric Spacecraft Charging Environments Using the LANL Magnetospheric Plasma Analyzer Data Set***
- ***Electrostatic Return of Contaminants***
- ***Mining CRRES IDM Pulse Data and CRRES Environment Data to Improve Spacecraft Charging/Discharging Models and Guidelines***

# Space Environments Testbed (SET) Concept

Microelectronics Testbed

P/L ↔ **Core (CPU)** ↔ P/L

P/L ↔ P/L

P/L P/L P/L P/L P/L

Induced Environment Monitors

P/L

P/L

P/L

From NASA Research Announcement (NRA)

From NRA & Partnering

SET Experiments

Experiment Interface Through SET Carrier

SET Host Spacecraft

P/L = Payload

Provided by the SET

Provided by Partners

06-20-03 LWS-SET to LWS MOWG

5 Categories for Investigations

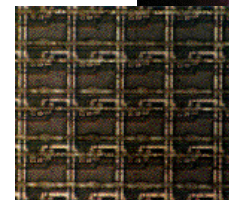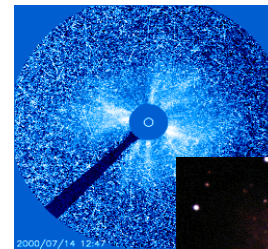**1. Characterization of the space environment in the presence of a spacecraft**

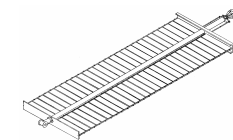**2. Performance improvement methodology for microelectronics used in space**

3. Accommodation and/or Mitigation of Space Environment Effects for detectors & sensors
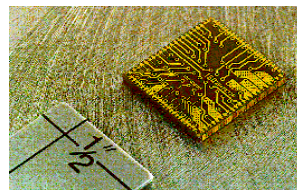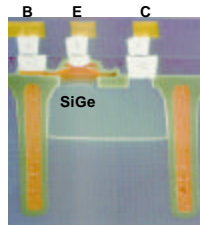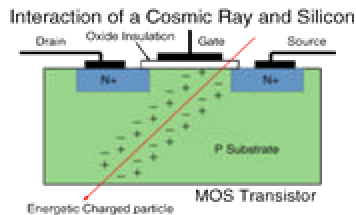
Ultra Low Power Electronics

Solar Array Degradation

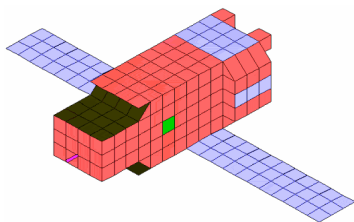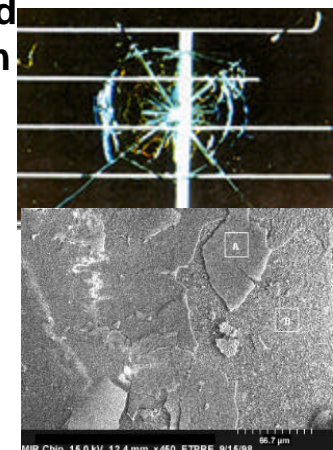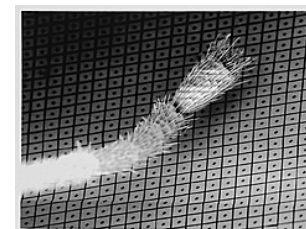**Noise & Degradation CCD, APS, IR, etc. Technologies**

4. Accommodation and/or mitigation of charging/discharging effects on spacecraft & spacecraft components
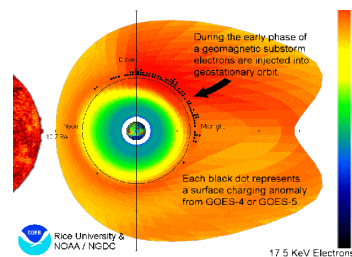
5. Definition of mechanisms for materials' degradation and performance characterization of materials designed for shielding from ionizing radiation

06-20-03 LWS-SET to LWS MOWG

7 Funded SET-1 Proposals

- **Development of Space-based Test Platform for the Characterization of Proton Effects and Enhanced Low Dose Rate Sensitivity in Bipolar Junction Transistors**
  - *Hugh Barnaby/University of Arizona*
    - **Characterize Enhanced Low-Dose Rate Sensitivity (ELDRS) and proton effects in bipolar junction transistors (BJT) using space data, a first**
- **Cosmic Radiation Environment Dosimetry and Charging Experiment**
  - *Clive Dyer/Qinetiq Ltd.*
    - **Monitor energetic proton fluxes and linear energy transfer spectra of ions to interpret single event effects data**
    - **Monitor electron fluxes and charging currents responsible for electrostatic charging**
    - **Monitor total ionizing dose as a function of shield depth to permit correlation with associated device degradation**

7 Funded SET-1 Proposals (Continued)

- *Energetic Charged Particle Spectrometer for Characterizing the Environment Around the LWS-SET Spacecraft*
  - *Gary Galica/Physical Sciences Inc.*
    - *Characterize the space environment in the presence of the spacecraft using a compact, energetic particle spectrometer with a flexible energy range*
- *Definition of the Mechanisms for On-Orbit Degradation of Variable Emissivity, Variable Absorptivity and Variable Reflectivity Materials Degradation*
  - *Gary Galica/Physical Sciences Inc.*
    - *Characterize and understand the performance as well as the mechanisms & degradation of new thermal control materials with variable absorptivity, emissivity, and reflectivity in an ionizing radiation environment in an active experiment (change as function of time)*

7 Funded SET-1 Proposals (Continued)

- **Space Flight Evaluation of the Radiation Shielding Performance of PolyRAD**
  - *Edward Long/Longhill Engineering*
    - ***Evaluate & document the space flight performance of PolyRAD, an advanced radiation spot shield material for reducing total absorbed dose (estimated 7X reduction) that enables the use of Commercial-Off-the-Shelf (COTS) microelectronics.***

- **Dosimetry Intercomparison and Miniaturization Experiment**
  - *Peter McNulty/Clemson University*
    - ***Flight test 6 different types of solid state dosimeters in space to:***
      - *Characterize total dose, single event upsets and displacement damage*
      - *Inter-compare accuracy, reliability, & operational characteristics*
      - *Test effects of small amounts of spot shielding using an array of microscopic dosimeters in a single chip*

7 Funded SET-1 Proposals (Continued)

- ***Total Dose and SEU Radiation Hardness Degradation due to the Addition of Built-In Self Test (BIST) to Mixed Signal Electronic Circuits***
  - *Bert Vermeire/Ridgetop Group Inc.*
    - ***Test a design rule checker and 2 BIST structures in a 0.25 um mixed signal application, a flash analog-to-digital converter (ADC)***

Where Are We & Where Do We Go From Here?

- *Access to space agreements in work*
- *Workshop to develop requirements for 2008 opportunities planned for Sept. 12*
- *Partner for focal plane array testbed in 2008 identified; agreement in work*
- *A new data mining NRA will occur NET 2007 due to funding availability*
  - *Genesis returned materials analysis would be a candidate for funding*

Backup Charts

COTS-1: Linear Enhanced Low Dose Rate Sensitivity (ELDRS)

Purpose

- Collect data in space to validate ground test protocols for linear bipolar devices that exhibit ELDRS
  - ELDRS is failure at a lower cumulative total integrated dose (< 10X) in space compared to accelerated ground test dose rates

NASA Benefit

- Provide more consistent performance & lifetime

NASA Application

- Linear bipolar devices are common in comparators and operational amplifiers -- basic building blocks in all NASA spacecraft & instruments

History

- Designed for STRV 1-d; will be re-built

Partners

- NAVSEA-Crane, Vanderbilt University, NASA GSFC, JPL, DoD, Industry

Leveraging

- The NASA Electronic Parts & Packaging Program (NEPP) delivers a ground test & technology guideline in FY 2002 (DoD co-funding)
- Devices provided by industry

SETPath Funding: $150K

Development Path

- None. Existing NAVSEA-Crane design with mission-specific modifications

Delivery Date: September 2002

Risk of Schedule Slip

- Low; existing design

COTS-1: Linear Single Event Transients (LSET)

Purpose

- Collect data in space to validate single event transient (SET) performance models & test protocols for linear bipolar devices

NASA Benefit

- Provide more consistent performance & lifetime; lower likelihood of LSET anomalies as observed in Cassini, MAP, & TDRSS

NASA Application

- Linear bipolar devices are common in comparators and operational amplifiers -- basic building blocks in all NASA spacecraft & instruments

History

- Designed for STRV 1-d; will be re-built

Partners

- Aerospace Corp., NASA GSFC, NAVSEA-Crane, Vanderbilt University, JPL, DoD, Industry

Leveraging

- The NASA Electronics Parts & Packaging (NEPP) supports development of ground radiation tests, protocols, & prediction models (DoD co-funding)
    - Ground test protocol will be issued in FY 2002
- Devices provided by industry

SETPath Funding: $75K

Development Path

- Existing design (Aerospace Corp) with mission-specific modifications

Delivery Date: September 2002

Risk of Schedule Slip

- Low; existing design

COTS-2: Digital COTS with FPGA Add-On

Purpose

- *Collect data in space to validate single event effect (SEE) & total integrated dose (TID) performance models for:*
  - *Commercial fuzzy logic processors;*
  - *Static random access memories (SRAM); &*
  - *Field programmable gate array (FPGA) logic devices*

NASA Benefit

- *Reduce design margins & provide more consistent performance in space*

NASA Application

- *SRAMS: Solid state recorders*
- *FPGAs: Replace custom solutions*
- *Fuzzy logic: Robotics, docking, & constellation management applications*

Partners

- *NASA GSFC, CNES, ONERA, TIMA*

Development Path

- *None. Board is already qualified to flight levels*

SETPath Funding

- *$25K for contract support of integration & test*

Delivery Date

- *Available now*

Risk of Schedule Slip

- *Low; existing hardware*

Ground data availability

- *Heavy ion & proton data in hand from Orsay, France*

History:

- *Built for STRV 1-d but not flown*

COTS-3: Optocouplers

Purpose
- Collect data in space to validate single event effect (SEE), total integrated dose (TID), and device displacement damage (DDD) performance models & test protocols for optocouplers
  - Parts of the models are also applicable to high-speed fiber optic links

NASA Benefit
- Reduce design margins & increase reliability
  - Anomalies on HST, TERRA, & TOPEX/Poseidon)

NASA Application
- Used to isolate electrical signals between spacecraft sub-systems & instruments

History
- Designed for STRV- 1d; STRV-1d devices will be updated

Partners
- NASA GSFC, JPL, DoD, Industry

Leveraging
- The NASA Electronic Parts & Packaging Program (NEPP) delivers a ground test & technology guideline in FY 2002 (DoD co-funding)
- Devices provided by industry

Development Path
- Existing design; mission-specific interface modifications & newer devices

SETPath Funding: $75K

Delivery Date: September 2002

Risk of Schedule Slip: Low; existing design

Ground data availability
- Heavy ion & proton data in hand

Field Programmable Gate Array (FPGA) Technology Concept Validation

Purpose

- *Collect data in space to validate single event effect (SEE), total integrated dose (TID), and device displacement damage (DDD) performance models & test protocols for COTS and environment-hardened FPGAs*

NASA Benefit

- *Provide more consistent performance in spacecraft electronics systems.*

NASA Application

- *Replace custom solutions in electronics system design at a fraction of the cost in virtually all NASA spacecraft; save power, weight, volume, & schedule*

History

- *Designed for STRV 1-d; devices will be updated to state of the art*

Partners

- *NASA GSFC, DoD, Industry*

Leveraging

- *The NASA Electronics Parts & Packaging Program & DoD support development of ground test protocols, guidelines, & technology development*
- *Devices provided by DoD & industry*

SETPath Funding Required

- *$75K*

Development Path

- *Existing design (NASA GSFC) with mission-specific modifications*

Delivery Date

- *September 2002*

Risk of Schedule Slip

- *Low – existing design*

Organizations Responsible for SETPath Experiment Components

Experiment - Who Does It	Data Collection in Space	Space Data Reduction	Engineering Guidelines Development	Data Infusion
Digital COTS with FPGA Add-On **COTS-2**	SETPath	SETPath, CNES	NASA NEPP; CNES	LWS SET, NASA
Linear Enhanced Low Dose Rate Sensitivity (ELDRS) **COTS-1**	SETPath	SETPath	NASA NEPP, JEDEC, DTRA, NAVSEA, NEPAG, ESA	LWS SET, NASA NEPP
Linear Single Event Transient (LSET) **COTS-1**	SETPath	SETPath	NASA NEPP, LWS SET NRA, DTRA, JEDEC, NASA NEPAG, ESA	LWS SET, NASA NEPP
Optocouplers **COTS-3**			NASA NEPP, LWS SET NRA, DTRA, JEDEC, NASA NEPAG, ESA	LWS SET, NASA NEPP
Correlative Environment Monitor & Dosimetry			N/A	LWS SET